EG&G RETICON

LC1901
Modular Line Scan Camera

Introduction

The LC1901 modular line scan camera is a compact, high performance, rugged industrial camera. It is constructed to operate and survive in harsh industrial environments while delivering the performance and precision required in the laboratory. The LC1901 features a single channel differential video format which allows video data rates of up to 10 MHz with exceptional noise immunity.

Applications for the LC1901 camera include high-speed data acquisition, dimensional gauging, noncontact measurement, process control and monitoring, optical inspection, biomedical imaging, remote sensing, and many other industrial and scientific applications.

Key Features

- Geometrically precise charge-coupled photodiode structure
- 256, 512, 1024, and 2048 element solid state image sensor selection
- 13 µm or 26 µm pixel aperture
- Single channel differential video output
- High-speed data rates to 10 MHz
- Line reset exposure control (electronic shutter)
- Antiblooming
- Rugged construction for industrial environments
- Differential digital I/O signals for electrical noise immunity
- Sensor is bore-sighted, angular-corrected, and referenced to precision registration holes
- Scan rates to over 35,000 scans per second
- Removable through-the-lens viewer (optional)

General Description

The LC1901 Line Scan Camera is a precision electro-optical instrument housed in a compact, lightweight, and extremely rugged enclosure. Internal construction utilizes shock absorbing interconnection materials and highly reliable hybrid circuitry to guarantee continued operation under conditions that could destroy conventional cameras.

The LC1901 camera senses light input from a scene and converts it into an analog video signal. The amplitude of the video is a linear function of the incident illumination from the scene. Electronic shuttering and antiblooming structures within the sensor ensure superior performance over a wide range of lighting conditions. Full control is provided over integration time and video data rate allowing the user to dynamically correct for variations in illumination found in "real-world" application environments. The LC1901 is available with 256, 512, 1024, or 2048 photo-element arrays so that the most stringent spatial resolution and speed requirements can be met.

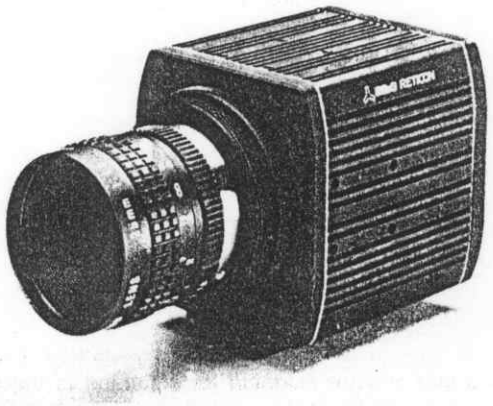


Figure 1. LC1901 Camera

Functional Description

The LC1901 camera contains a high performance line scan image sensor which converts incident light on each photodiode into discrete charge packets. After an appropriate integration period, the charge packets are transferred into two high-speed CCD shift registers and transported to the output of the device. The two channels of video from the sensor are processed into a single channel of sampled-and-held serial analog data by a unique hybrid microcircuit designed by Reticon to deliver peak performance and exceptional reliability. This serial data stream of contiguous pixels allows for more efficient A/D conversion hardware designs.

Camera operation is controlled by three externally generated, differential input signals. The frequency of the master clock input determines the video data rate; the period of the line transfer input defines the line scan rate; and the line reset signal, used in conjunction with the line transfer input, controls the integration period. Th e flexibility of this arrangement allows video data rates up to 10 MHz, line rates exceeding 35,000 scans per second, and provides an electronic exposure control.

This direct control over camera speed and pixel integration time allows the data rate to be set to a convenient readout speed for external processing hardware while allowing an integration time appropriate to capture higher speed events. The electronic exposure control combined with the antiblooming circuitry allows the camera to operate over the widest possible range of lighting conditions.

345 POTRERO AVENUE SUNNYVALE, CALIFORNIA 94086-4197 (408) 738-4266 FAX: 408 738-6979

Electrical Configuration

Camera operation requires ±12VDC and +5VDC power, a single phase clock, and a line transfer pulse. All digital input and output signals are differential line pairs conforming to EIA RS422 specifications. The video channel is a 100Ω, differential output for superior immunity to external noise. Cable assembly, CA1902BFN-011, for power and signal transmission is available in an eight foot length. The custom shielded cable used for the CA1902 is available from Reticon in lengths of one hundred foot multiples for operation at remote locations or in electrically noisy environments.

LC1901 series camera electronics are contained on three custom hybrid circuit modules within the camera housing. The circuit modules process control signals from the user, generate bias and drive signals for scanning of the photodiode array, and present the analog video and digital output signals to the user. All electrical connections to and from the camera are via a single 25-pin D-subminiature connector on the camera's rear panel.

Operation

Camera video output is produced by scanning the array at a rate determined by the external master clock input signal. That rate may be any value from 20 KHz to 10 MHz and produces a single train of sampled-and- held video data having an amplitude proportional to the light intensity and the line scan integration time.

The video output is a contiguous pixel data stream with a dynamic range of greater than 2000:1 (peak video/p-p noise, excluding clock coupling) for applications that demand high gray scale resolution. The "full line dynamic range" (peak video/peak-to-peak dark pattern) is typically better than 48 dB which provides superior performance in binary o r thresholding applications.

The line scan time is determined by the time interval between external line transfer pulses. A long integration time is desirable for high sensitivity, while a short line scan time is desirable to obtain a sharp image of rapidly moving objects. The line scan time may be any value between (N+32) x 100 nanoseconds and 40 milliseconds, where N is the number of array elements. Integration times longer than 40 ms can introduce higher levels of dark signal which reduce the dynamic range of the sensor. Longer integration times are possible if the camera is cooled to reduce the dark current. The specific characteristics of the application such as light level and rate of object motion will determine the optimum setting.

The camera block diagram, see Figure 2, illustrates the functional flow of signals and the connector pin assignments for LC1901. The timing characteristics and requirements are typified in Figure 3. The optimum circuit synchronization the falling edge of camera line transfer (CLT) should be used as a reference to the timing for the start of the video (see Note 2). Line Enable (LEN) is provided as a convenience for less than 8 MHz MCLK camera operation.

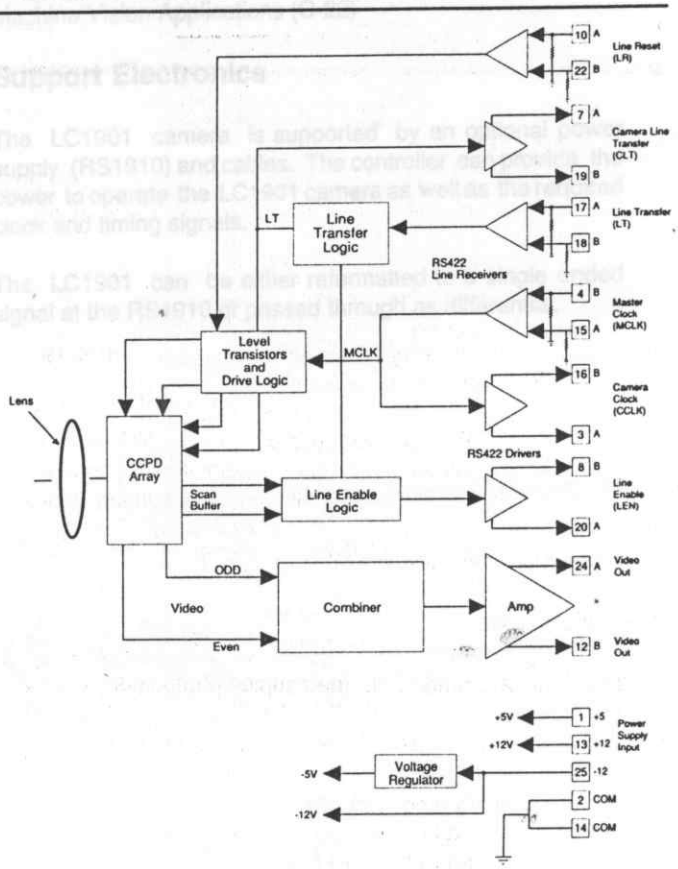


Figure 2. Camera Block Diagram

Sensitivity and Spectral Response

The LC1901 contains a high quality silicon photodiode line array that is responsive to wavelengths of light from below 300 nanometers (UV) to 1100 nanometers (near IR) (see Figure 4). Relatively high responsivity is maintained even in the blue end of the spectrum, because there is no inter fering structure covering the photodiode as is typical of competitive sensors. The response of the array to illumination is a function of sensor geometry and integration time. The LC1901 camera is available with standard (13 µm) and wide (26 µm) aperture devices.

Typical applications for these devices utilize visible light, therefore, sensitivity and photoresponse uniformity are specified using a light source with the spectral distribution shown by the dotted line in Figure 4. This spectral distribution is produced by filtering a 2870°K Tungsten source with a Fish Schurman HA-11 heat absorbing filter 1 mm thick.

Construction

The rugged LC1901 camera is constructed to survive and operate reliably under punishing shock and vibration conditions. The LC1901 can withstand shock up to 100G (peak) and random vibration in excess of 20G (RMS).

ne sensor is precisely aligned to the registration pin noles. That allows the camera to be easily removed and remounted as may be necessary for lens cleaning or equipment servicing without complicated optical realignment. All LC1901 camera image sensors are aligned at the factory for X, Y and rotation with respect to the precision registration holes.

Optical

All LC1901 cameras except the 2048 element version are supplied with adaptors for "C-mount" type lenses. The LC1901, with the 2048 element array, is supplied with an adaptor for mounting Nikon "F" bayonet type lenses or accessories.

An optional through-the-lens viewer (Model CX9411) is available for use with the LC1901 camera to greatly simplify installation and alignment. With the appropriate lens adaptor, "U" or "F" mount optics and accessories can be used with the viewer. More information on selecting lenses, adaptors and extension tubes is available on Reticon's Optical Calculation Worksheet.

Lenses and Optical Accessories

Reticon offers an extensive line of lenses and optical accessories for the LC1901 camera. Products range from lenses and extension tubes to high performance light sources. All Reticon modular cameras have identical optical and mechanical configurations so that lenses and accessories can be interchanged from camera to camera. Virtually any field of view or magnification requirement can be satisfied using available lenses and optical accessories.

Mounting Accessories

EG&G Reticon offers a complete line of high quality mounting accessories for the LC1901 camera to facilitate optimum camera positioning. These include a heavy-duty right angle precision mounting plate, a circular precision mounting plate, and a camera head accessory tripod mounting block. One tripod mounting block is supplied with the camera.

Reticon also offers a variety of other camera products. Contact your local sales office for additional information or a demonstration.

Application Support

Reticon maintains a staff of highly skilled applications engineers to provide technical assistance and in-depth applications information. A library of technical articles and application notes is also available to assist our customers in the use of Reticon's machine vision products. Some examples of these are the following:

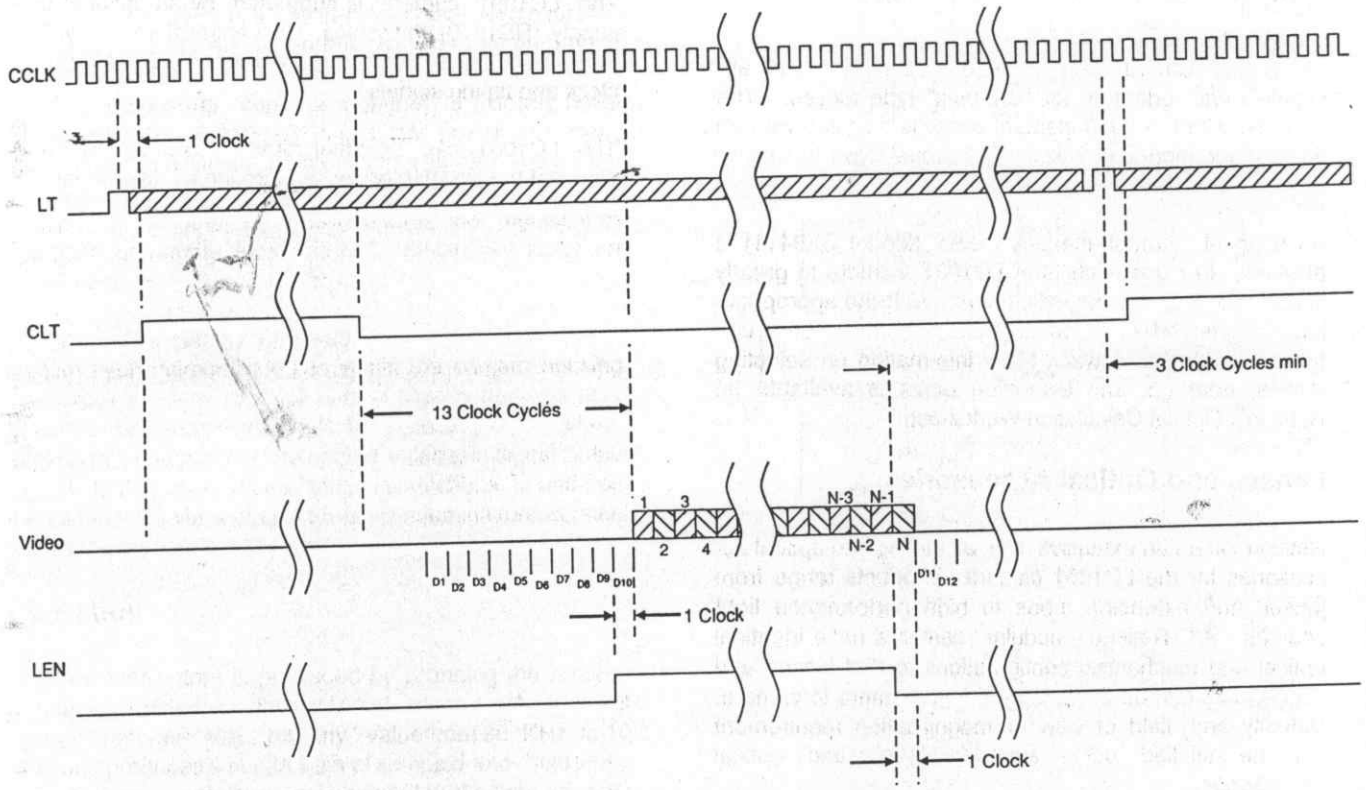
Depth of Field Characteristics using Reticon's Image Sensing Arrays and Cameras (#127)
Optical Calculation Worksheet (#126)
Design Considerations for a Solid State Image Sensing System (A-6)
Modular Solid State Machine Vision Camera (C-21)
Practical Illumination Concept and Technique for Machine Vision Applications (C-22)

Support Electronics

The LC1901 camera is supported by an optional power supply (RS1910) and cables. The controller can provide the power to operate the LC1901 camera as well as the required clock and timing signals.

The LC1901 can be either reformatted to a single ended signal at the RS1910 or passed through as differential.

Noninverted Differential Signals shown



Minimum LT repetition rate is N (elements) + 32 clock cycles

D3 through D6 may be used as the dark reference

Figure 3. Timing Diagram

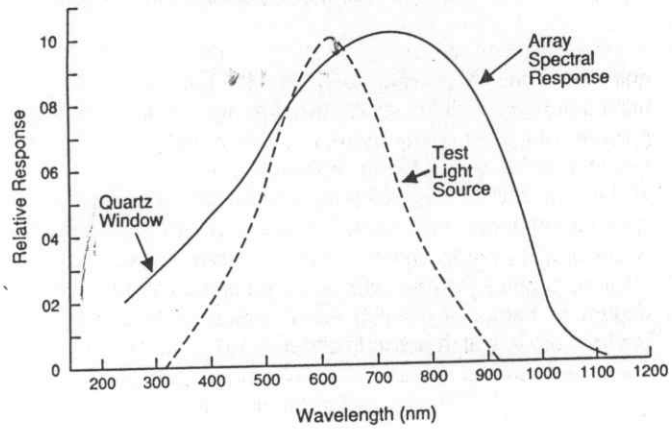


Figure 4. Relative spectral response as a function of wavelength. Dotted line shows the spectral distribution of light source used for sensitivity measurements. Measurements taken using full array illumination and averaged relative output at test spectral frequencies. The standard LC1901 camera devices have quartz window.

The camera electronics is housed in a sturdy aluminum case. The front hybrid microcircuits are laminated onto aluminum mounting plates which function as efficient heat transfer devices to the case. When used in extremely hot environments, the camera electronics may be conveniently cooled simply by cooling the case. All hybrids are thermo-mechanically connected to the case. The image sensor is thermally attached to the front aluminum plate and electrically connected to the front hybrid. The hybrids are interconnected via shock absorbing elastomeric conductors and the interconnect pc board is connected to the rear hybrid and the case-mounted D-subminiature connector via a flexible conductor strip.

The camera is provided with a standard 1/4-20 UNC tripod mounting plate which can be mounted on any of four sides of the camera case. The hole pattern used to fasten the tripod mounting plate can also be used to rigidly mount the camera assembly. An optional right angle bracket and circular mounting plate is also available for mounting flexibility. These mounting options contain registration pins which are designed to mate with corresponding precision holes on the camera face.

Specifications

Sensor Characteristics	
Center-to-center spacing	13 µm
Aperture width	13 µm or 26 µm
Spectral response	300 to 1100 nm

Operational Features	
Dynamic range	>2000:1 typical [5]
Video data rate	To 10 MHz
I/O signals	Differential digital RS422
Video level	1.5V typical into 100Ω line to line)
Video output impedance	100Ω line to line
Weight	18 ounces (511 gm)
Dimensions	2.5" (H) x 2.5" (W) x 2.85" (D) 6.35 cm (H) x 6.35 cm (W) x 7.24 cm (D)

Control Signals	
Master clock (MCLK)	Controls readout speed
Line transfer (LT)	Initiates scan readout
Camera clock (CCLK)	MCLK synchronized to video
Enable (LEN)	Indicates presence of valid video [8]
Line reset (LR)	Reset all photodiodes to zero integration level

Power Requirements	
+12V DC	295 ma (typ)
-12V DC	70 ma (typ)
+5V DC	350 ma (typ)
Input power	6W @ 10 MHz (typ) *

Performance	
Full line signal-to-noise ratio	>48 dB [4,6,7]
Light response nonuniformity	±6% max [1,2,4,7]
Saturation exposure	.45 microjoule/cm² @ 13 µm aperture .22 microjoule/cm² @ 26 µm aperture
Exposure time (max) [3]	40 ms @ 25°
Shock	100G (peak)
Random vibration	20G (RMS)

Temperature	
Operating	0 to 55°C
Storage	-40 to 80°C

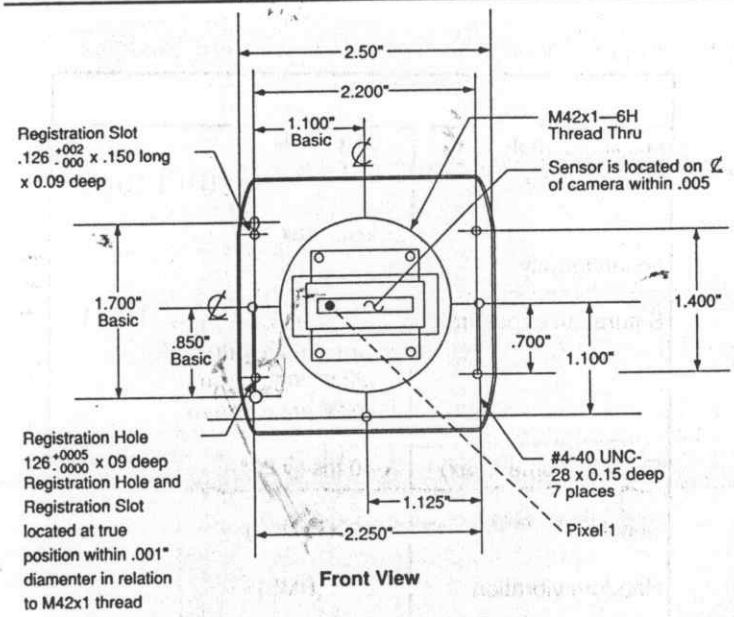
* Power consumption decreases as clock rates decrease

Notes

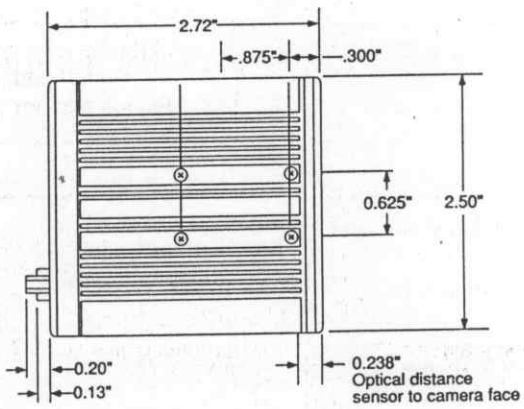
1. Light source is a 2870°K tungsten lamp filtered using a Fish Schurman HA11, 1 mm thick filter.
2. Measured with uniform illumination at approximately 50% of saturation (first and last pixels ignored).
3. This exposure time will cause a dark leakage current of 8% or less.
4. Use of line reset causes an increase in the fixed pattern.
5. Dynamic Range = V_{SAT}/p-p noise (excluding clock coupling) @ 25°C
6. Full line S/N ratio = V_{SAT}/p-p fixed pattern noise
7. At 25°C with 1 msec integration time, F data equals 200 KHz
8. For MCLK rates in excess of 8 MHz, use trailing edge of CLT to establish video synchronization.

Ordering Information

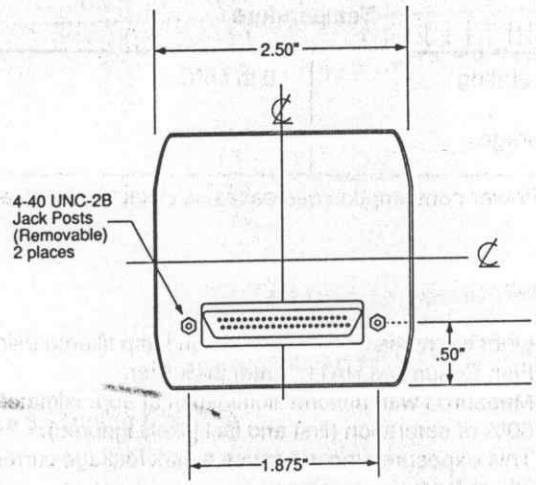
Part Number	# of Elements	Standard Mount	Aperture Width
LC1901DAN-011	256	C	13 µm
LC1901FAN-011	512	C	13 µm
LC1901HAN-011	1024	C	13 µm
LC1901KAN-011	2048	F	13 µm
LC1901DKN-011	256	C	26 µm
LC1901FKN-011	512	C	26 µm
LC1901HKN-011	1024	C	26 µm
LC1901KKN-011	2048	F	26 µm



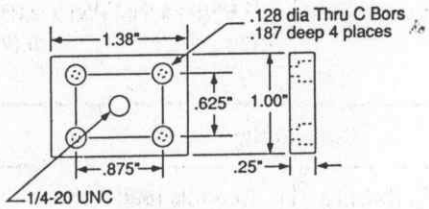
Front View



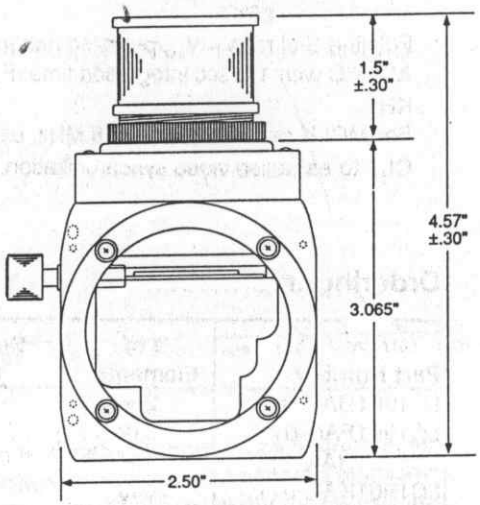
Side View



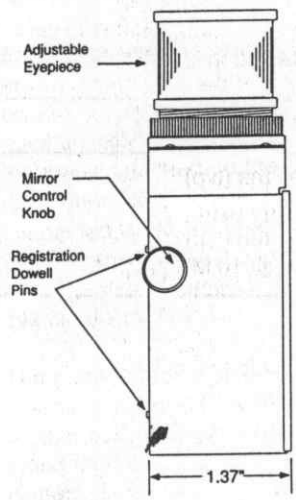
Back View



Standard Tripod Block
Mounting Accessory



Front



Side

Through-the-lens Viewer (optional)

Figure 5. Mechanical Dimensions

055-0240
October 1990